off DC equal to twice AD, from D erect a perpendicular, and with radius AC = 3DA cut off DP; AC and AP are sides of the lozenge ACEP, which fulfils the required conditions. It is manifest that from this lozenge the remaining two lozenges and also the six trapeziums can be immediately constructed.

The triangular pyramid which terminates the bee's cell may be inscribed in a sphere whose diameter is three times the side of one of the edges of the pyramid. The base of this pyramid is an equilateral triangle, the side of which is $h\sqrt{3}$, and whose circumscribing circle has $2h$ for its diameter. This diameter is a chord of the spherical segment whose versed sine is x. Hence, if D is the diameter of the sphere in which $2h$ is a chord, $x\mathrm{D}=h^2+x^2$, but also $h=2\sqrt{2}x$, and $s=3x$, whence

$$\mathrm{D}=9x=3s.$$

We have also

$$\mathrm{D}=\frac{9h}{2\sqrt{2}}>2h.$$

Hence the sphere contains within it all that part of the bee's cell bounded by the three lozenges, together with as much of the hexagonal prism as may be measured by twice the side of a lozenge on the shorter edge of the prism.

This result, together with the extremely simple mode now given for constructing the figure, divests the problem of the complexity and difficulty with which it was formerly sometimes regarded, and it may also possibly enable the naturalist to more readily explain the action of the bees in moulding the cells of the honeycomb to their observed shapes.

II. "A New Method for the Quantitative Estimation of the Micro-organisms present in the Atmosphere." By PERCY F. FRANKLAND, Ph.D., B.Sc., F.I.C., F.C.S., Assoc. Roy. Sch. Mines. Communicated by Professor FRANKLAND, D.C.L., F.R.S. Received November 15, 1886.

(Abstract.)

The author commences by giving a sketch of some of the more important methods which have been devised for the bacterioscopic examination of air. In these he includes the experiments of Pasteur, who was the first to show that the air at different places varied in the number of micro-organisms which it contained, and of Tyndall, who proved that the microbes suspended in the air become rapidly deposited in the absence of any disturbing influence. He further

describes the process of Freudenreich and Miquel for the quantitative estimation of the bacteria in air, and points out the great advance which has been made upon their method in the adaptation by Koch, and later by Hesse, of a solid nourishing medium for their investigation. In reviewing these different processes he draws attention to the advantages and disadvantages attending them, and proceeds to describe a new method which he has devised, and in which he has endeavoured to overcome some of the objections to which the others are open.

The first experiments consisted in aspirating a definite volume of air through plugs of either glass-wool or sugared glass-wool, and mixing them by violent agitation with a definite volume of either broth or sterilised distilled water.

A portion of this liquid was then added to gelatine-peptone, and plates were poured in the usual manner.

In this way a much larger volume of air was capable of being examined than was possible by Hesse's method, whilst at the same time the solid medium, with its advantages, was retained. The experiments, however, show that although in many cases the results of two or more plates poured from the same mixture were fairly uniform, yet discrepancies did occur, and were sometimes very considerable, pointing to the fact that the organisms had not become evenly distributed throughout the liquid; also as only a portion of the air aspirated was capable of being examined, a very much larger volume of air had to be used in order to give a sensible result.

This objection, which applies equally to Miquel's method, which rests upon the assumption that it *is* possible to equally apportion out into a series of flasks or tubes the organisms contained in such a liquid, led the author to abandon the plate process, and to devise a method which should enable the whole volume of air aspirated to be examined.

The method consists essentially in aspirating a known volume of air through a glass tube, containing two sterile plugs, consisting either of glass-wool alone, glass-wool and fine glass-powder, glass-wool coated with sugar, or sugared glass-wool and fine sugar-powder. The plugs are so arranged that the first one through which air is drawn is more pervious than the second. After a given volume of air has been aspirated, the two plugs are transferred respectively to two flasks, each containing melted sterile gelatine-peptone, and plugged with sterile cotton-wool stoppers. The plug is carefully agitated with the gelatine, so as to avoid any formation of froth, and when the plug has become completely disintegrated and mixed with the gelatine, the latter is congealed, so as to form an even film over the inner surface of the flask. On incubating these flasks at a tempe-

rature of 22° C., in the course of four to five days the colonies derived from the organisms contained in the plugs make their appearance, and can be readily counted and further examined.

A large number of experiments were made with a view of testing the accuracy of the process. For this purpose experiments were conducted, using sometimes single plugs, and sometimes double, and it was almost invariably found that all the organisms were deposited on the first plug, the second plug in the very exceptional cases when it did yield anything, containing rarely more than one organism.

In connexion with Hesse's method, it was found that in experiments performed in the open air, when a blank Hesse tube was exposed side by side with the one through which air was being aspirated, a number of organisms also became deposited in the blank tube, thus introducing an important source of error in the quantitative results obtained by Hesse's process. In the flask method, on the contrary, such blank tubes rarely contained any organisms, and in no case more than a vanishing proportion of those present in the other tube. This shows that whereas in Hesse's apparatus any disturbance of the air during the experiment vitiates the accuracy of the result, in the flask method such disturbances are immaterial.

On the other hand, in the absence of aërial currents, there was a remarkable concordance between the results obtained by Hesse's method and by the "flask method." This is important, not only as showing the quantitative accuracy of the new method, but by clearly demonstrating that the organisms present in the air exist in an isolated condition, and not in aggregates, as suggested by Hesse. It will be remembered that the plug is violently agitated with the gelatine-peptone, during which operation such aggregates would undoubtedly be broken up wholly, or, any rate, partially; it would, therefore, be reasonable to expect that the "flask method" would yield a larger number, and possibly a far larger number of colonies than those formed in Hesse's tubes, but as, on the contrary, the numbers agree, under the circumstances described, in so remarkable a manner, it points to the fact that they exist in an isolated condition.

The paper is illustrated with drawings and photographs.

The following are the principal advantages which the author claims for the "flask method."

1. The process possesses all the well-known advantages attaching to the use of a solid medium.

2. The results, as tested by the comparison of parallel experiments, can lay claim to a high degree of quantitative accuracy.

3. The results, as tested by control experiments, are not appreciably affected by aërial currents, which prove such a disturbing factor in the results obtained by some other methods.

4. The collection of an adequate sample of air occupies a very

short space of time, so that a much larger volume of air can be conveniently operated upon than is the case with Hesse's method. Thus whilst the aspiration of 10 litres of air through Hesse's apparatus takes about three-quarters of an hour, by the new method about 48 litres can be drawn through the tube in the same time, whilst a better plan is to take two tubes and alternately draw a definite volume of air through each, as by this means duplicate results are obtained.

5. As the whole plug, upon which the organisms from a given volume of air are deposited, is submitted to cultivation without subdivision, no error is introduced through the multiplication of results obtained from aliquot parts, and all the great difficulties attending equal subdivision are avoided.

6. The risk of aërial contamination in the process of *flask-cultivation* is practically *nil*.

7. The apparatus required being very simple and highly portable, the method is admirably adapted for the performance of experiments at a distance from home, and in the absence of special laboratory appliances.

III. "Further Experiments on the Distribution of Micro-organisms in Air (by Hesse's method)." By PERCY F. FRANKLAND, Ph.D., B.Sc., F.I.C., F.C.S., and T. G. HART, A.R.S.M. Communicated by Professor FRANKLAND, D.C.L., F.R.S. Received November 22, 1886.

(Abstract.)

The authors record a number of experiments, made with Hesse's apparatus, on the prevalence of micro-organisms in the atmosphere. The results are intended to form a supplement to those already obtained by one of the authors, and published in the last volume of the Society's 'Proceedings' (vol. 40, p. 509). The greater number of the experiments have been performed on the roof of the Science Schools, South Kensington, the air of which has now been under observation at frequent intervals during the present year. The authors point out the variations according to season, which have taken place in the number of micro-organisms present in the air collected in the above place. The average results obtained were as follows:—